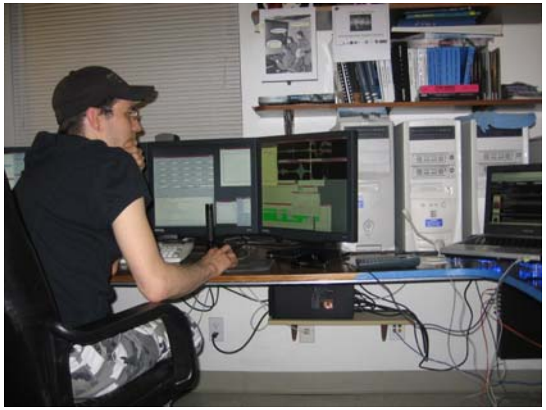


Separated Fringe Packets

Results and Prospects

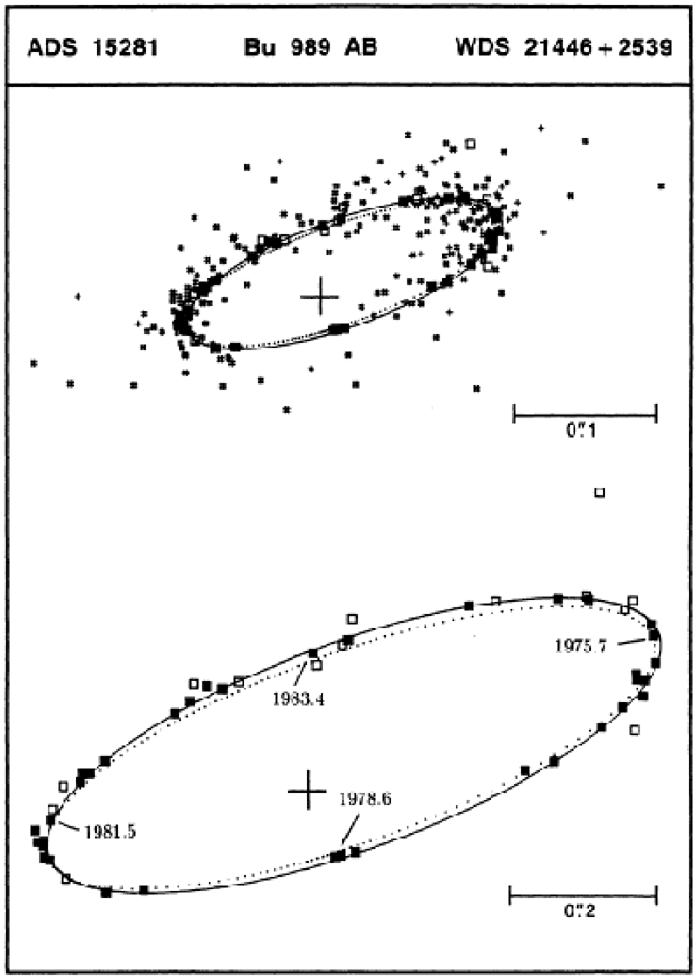
Brian Mason, Chris Farrington, Theo ten Brummelaar, Nils Turner, et al.

Astrometric Bootstrapping

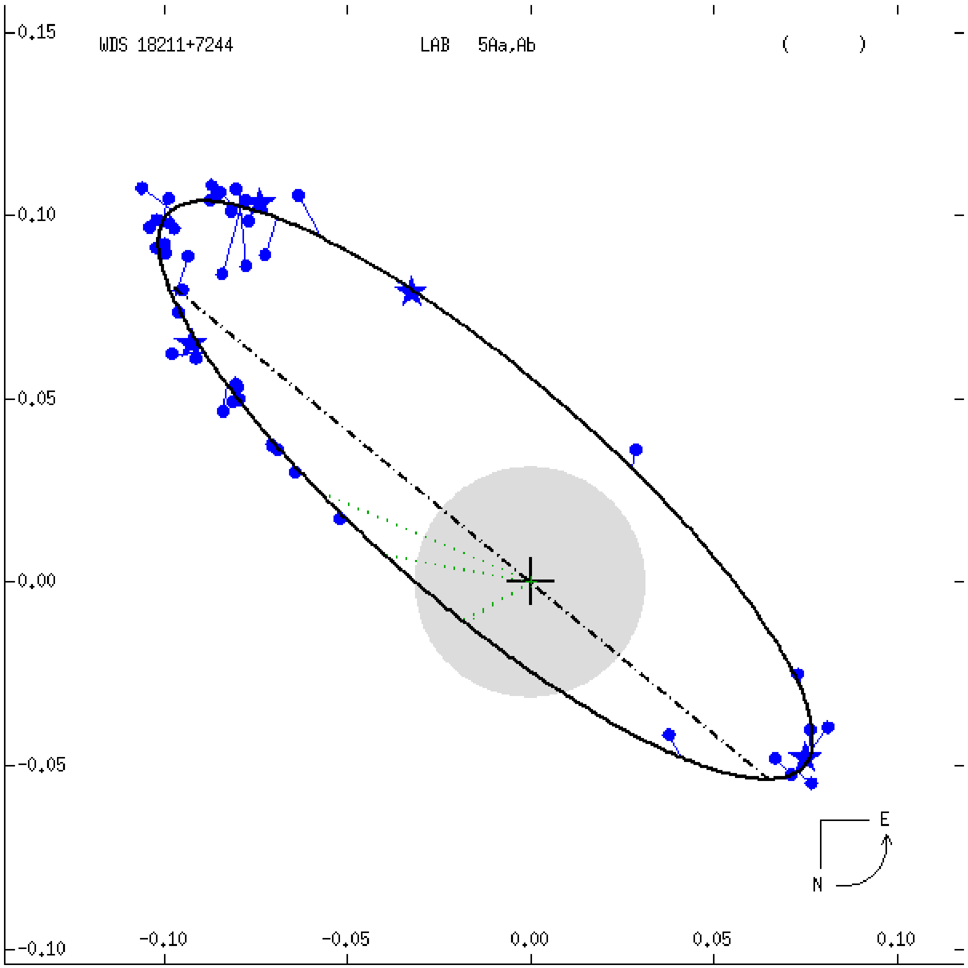
- When a higher resolution capability is applied to double stars, pairs which were previously at the limit can be routinely observed.
- Historically, this was through telescope aperture but also can be applied to a method of collection.
- In the 19th Century successive Clark refractors, at the time the largest telescopes in the world, were able to resolve closer, known white dwarf companions of Sirius and Procyon.

Speckle Interferometry

- Through both telescope aperture (access to 4-5m telescopes) and the technique to take advantage of it, speckle interferometry accomplished this from the 1970s.
- Clouds of micrometry measures became the "string of pearls" associated with speckle data, most obviously seen in the 28 orbits paper (Hrt1989).
- Separated Fringe Packet (SFP) work is optimized to take these pairs at the limit of speckle capabilities and make a similar gain.

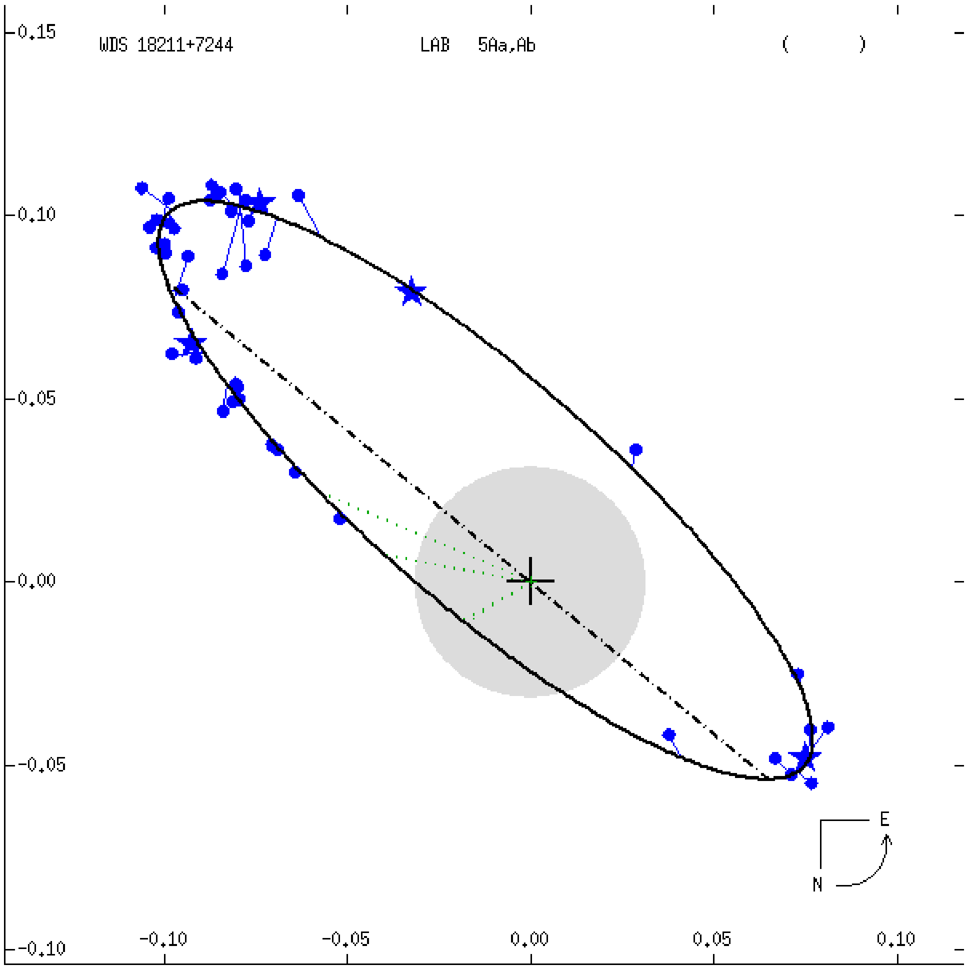


Generic Figure Description



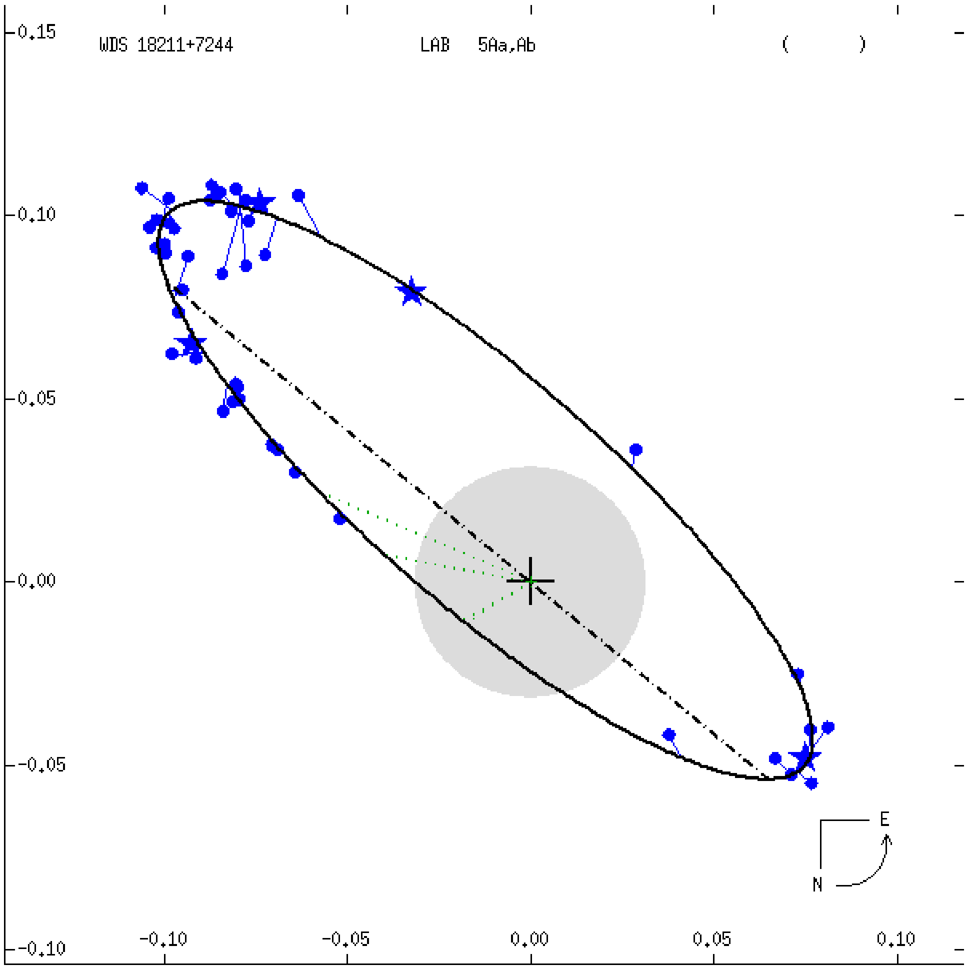
- Scale is arcseconds
- Lower right gives directions and motion
- The solid curve is the new orbit calculation. If a dashed curve is present it is the current “best” orbit.
- Filled blue circles are speckle interferometry points
- Stars are CHARA Array data
- Each point connected to the predicted orbit position by an “O-C” line
- Solid disk centered on origin is the V band resolution limit of a 4m telescope (30 mas)
- Broken line is the line of intersection of the plane of the orbit with the plane of the sky

χ Draconis



- CHARA Array data from 0^0 is from June & September 2006 and August & October 2007.
- Three dashed lines from origin indicate predicted position on May 4, 11, and 18, 2009.
- Another scheduled observation June 1 just after periastron (not plotted).

χ Draconis

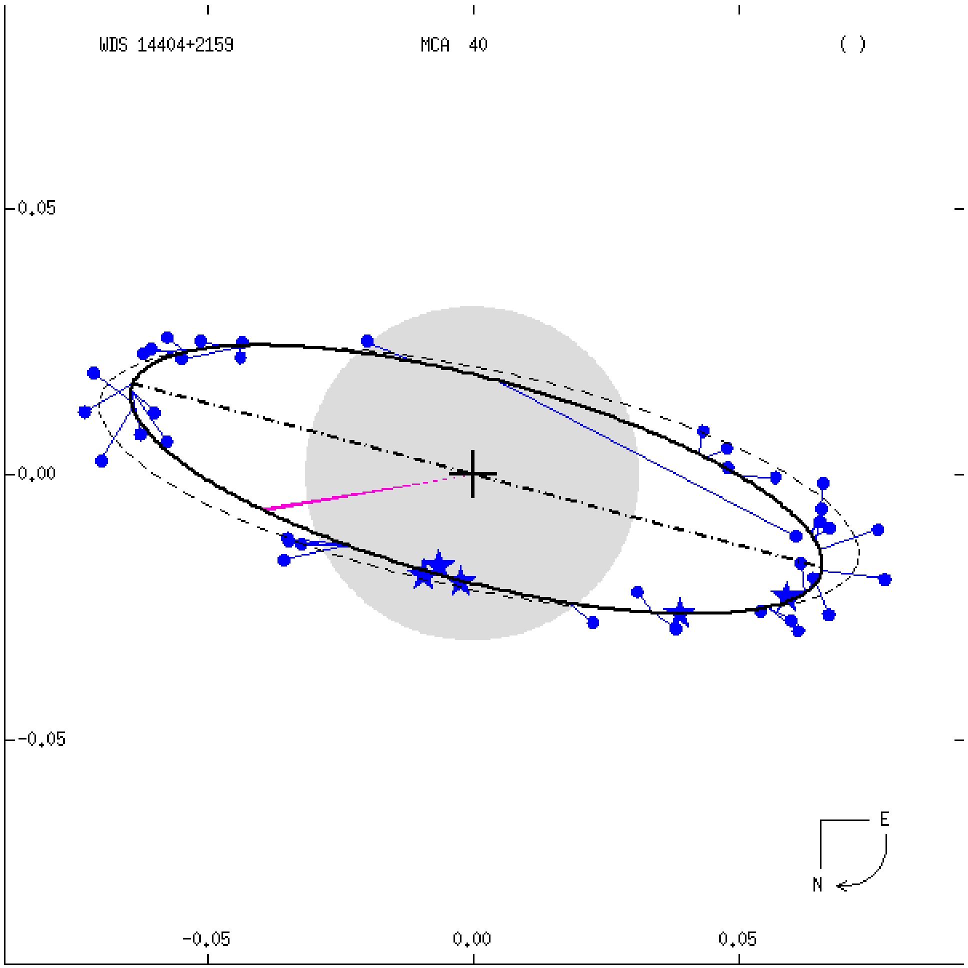


- The orbit (Pbx2000b) is quite good:

$$\mathcal{M}_a = 1.03(0.05)\ \mathcal{M}_\odot$$
$$\mathcal{M}_b = 0.73(0.024)\ \mathcal{M}_\odot$$
$$\pi \quad = 122(2.1)\ \text{mas}$$

- At that time, χ Dra had completed 35 revolutions since the first resolution (Lab1974). As of the last Array resolution it is now 45 revolutions.
- The shortcoming of the relative astrometric orbit was the lack of coverage near periastron, predicted for May 31 this year.
- The next orbit will have 33% more orbits, 20% more data, and cover periastron.

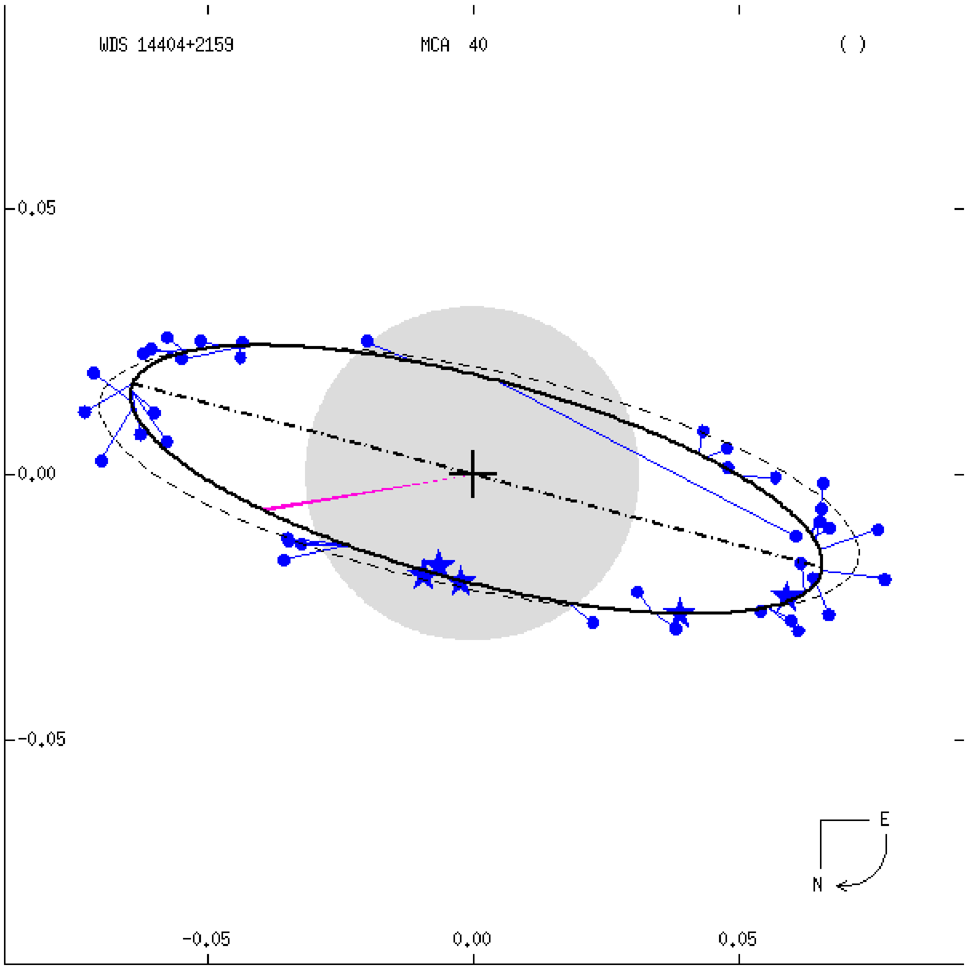
SFP3: HD 129132



- CHARA Array data from 90^0 is from May 2006, July 2007, and May, July and August 2008.

- The fuscia wedge is where the secondary is predicted to be from May 4 to May 18.

SFP3: HD 129132

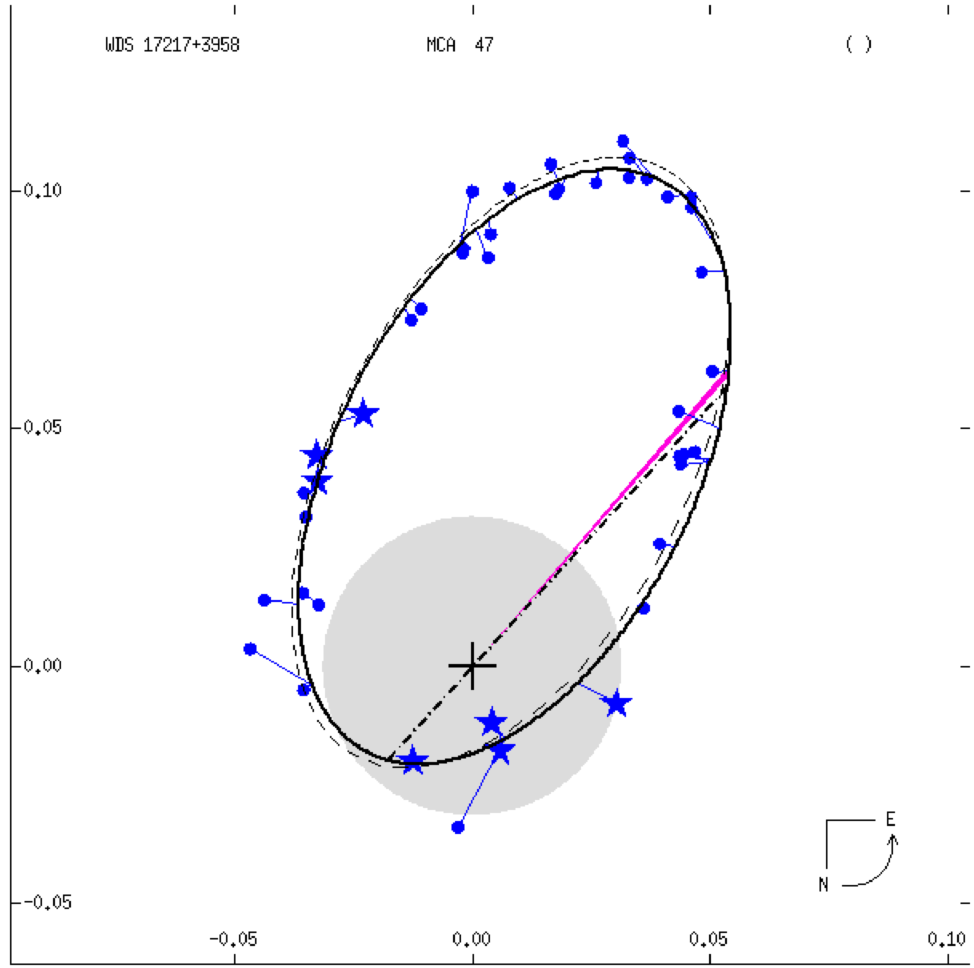


- A spectroscopic triple, the orbit (Scf1991) is good and includes solutions for both the closer (P = 101.6d) as well as this pair.
- This system may be appropriate for an analysis like that for CHARA 96 where the wider pair serves as a calibrator for a baseline solution of the inner pair.
- Considering the wider pair only, at the time of the dashed orbit shown here, HR 5472 had completed ~1.3 revolutions since the first resolution (McA1979b). As of the last Array resolution it is now ~3.4 revolutions.
- Coverage due north now adequate. The object will be due south from late 2012 to early 2013.
- Orbit is obvious need of correction.

SFP3: HD 157482

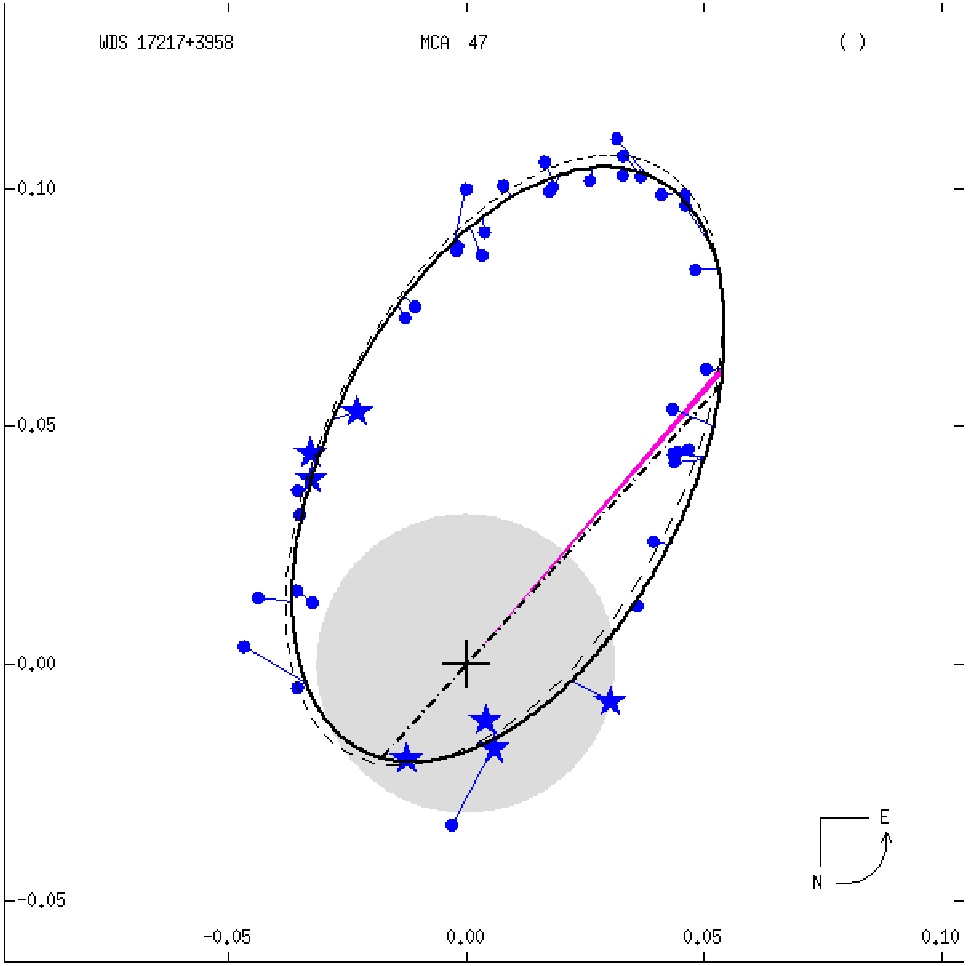
- CHARA Array data from 180^0 is from May, June & July 2007 and May, July & August 2008.

- The fuscia wedge is where the secondary is predicted to be from May 4 to May 18.



SFP3: HD 157482

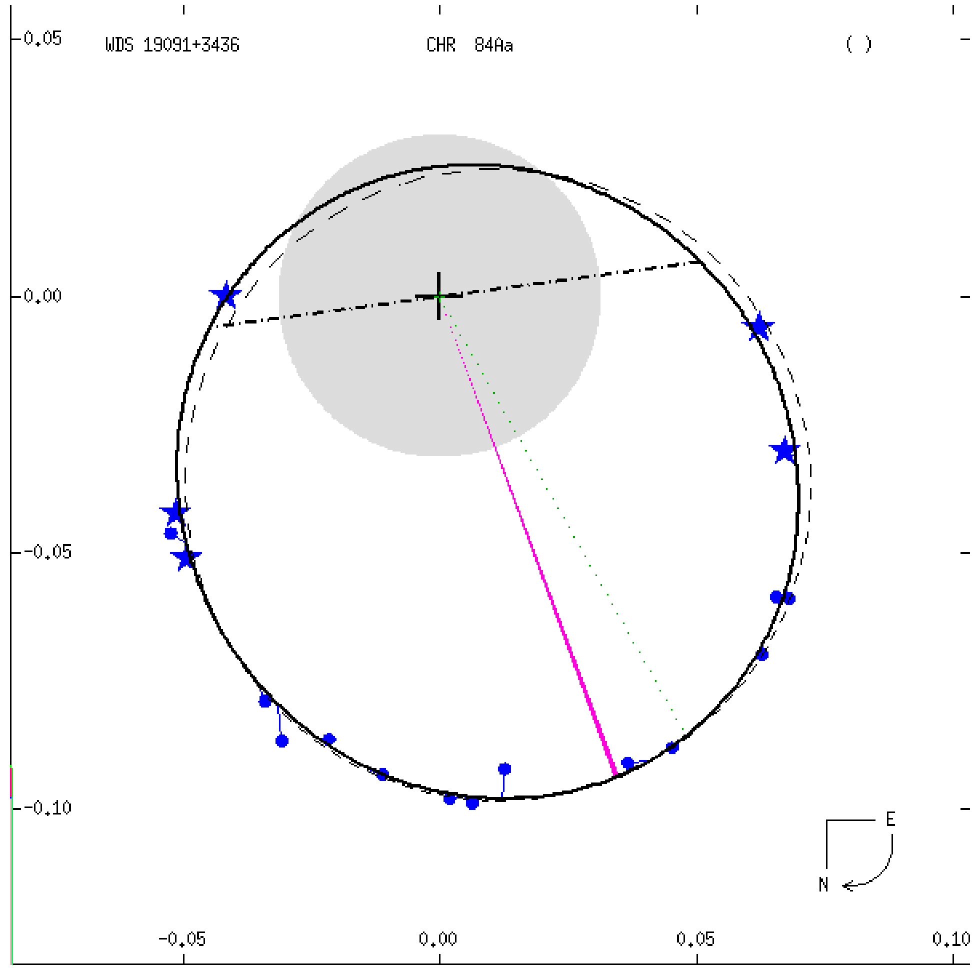
- Like HR 5472, this pair is also a spectroscopic triple with a good recent orbit (Mut2008) which may be appropriate for a combined approach.
- Array data at crucial phases not previously observed can make improvements on the dashed orbit shown here.
- The larger than typical O-C for some Array data is due to inadequate rotation with one baseline used, or difficulties extracting separated fringe packet data at projected separations which were quite close.



SFP2: HD 178911

- CHARA Array data from 0^0 is from June, July & October 2007 and May & August 2008.

- The dashed line is the predicted position May 18, and the fuscia wedge is 10-12 August.



SFP2: HD 178911

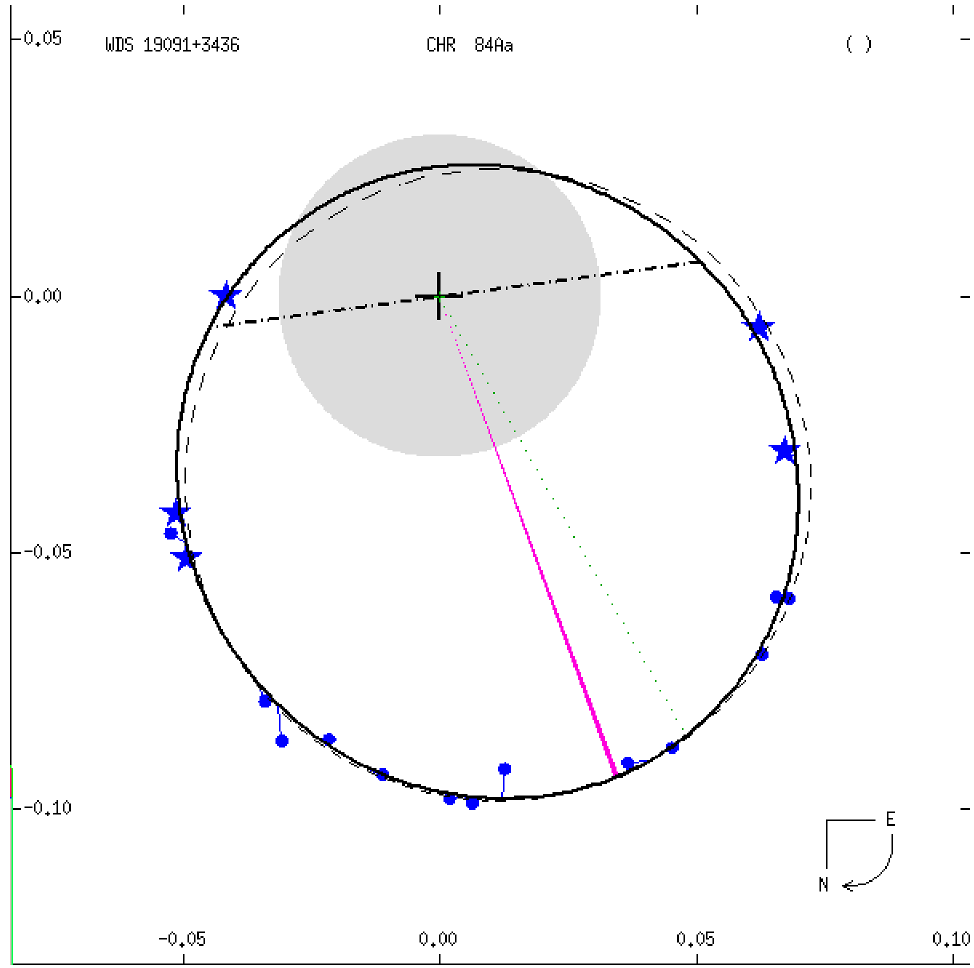
- While the combined solution orbit (Tok2000) appears superficially adequate the errors are large due to the paucity of resolved data at the time (N=6) :

$$\mathcal{M}_a = 1.07\ (0.37)\ \mathcal{M}_\odot$$
$$\mathcal{M}_b = 0.84\ (0.29)\ \mathcal{M}_\odot$$

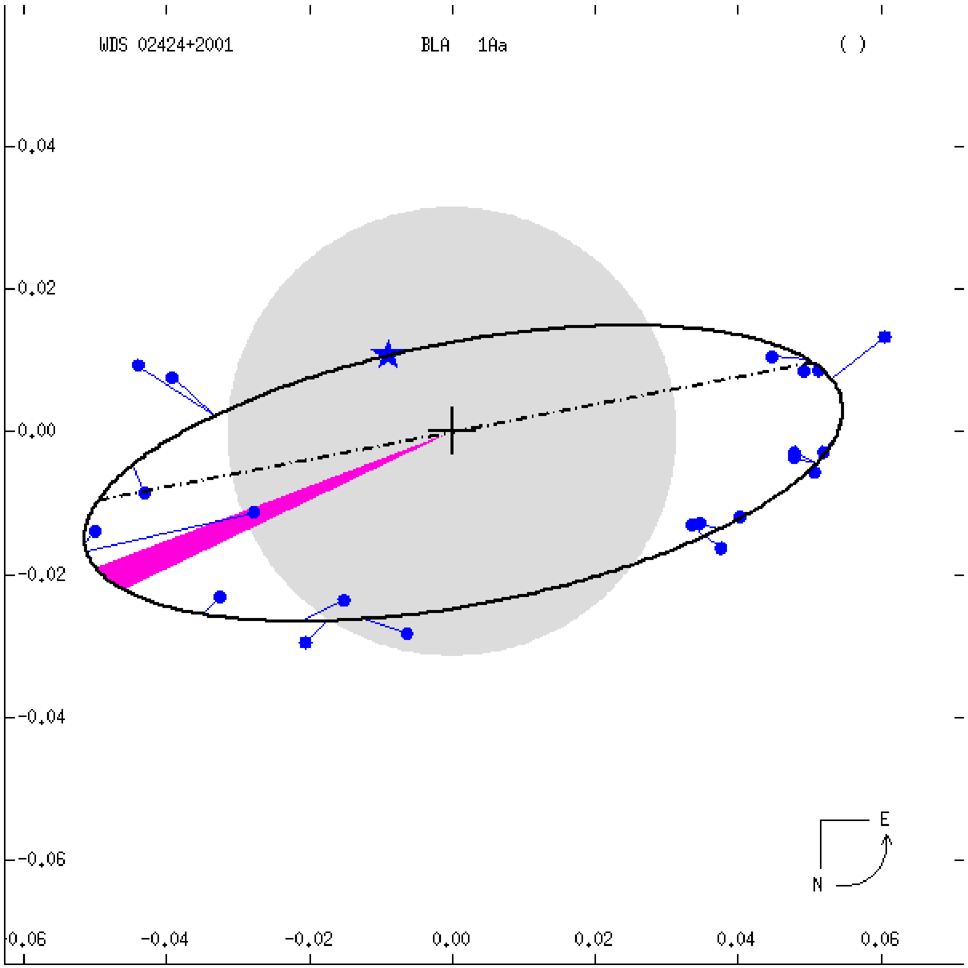
- Now, with over three times the data the errors, and masses, are getting much smaller:

$$\mathcal{M}_a = 0.724\ (0.045)\ \mathcal{M}_\odot$$
$$\mathcal{M}_b = 0.562\ (0.043)\ \mathcal{M}_\odot$$

- The pair was last at closest approach during the 2007 winter shutdown. It will next be there in mid 2011.

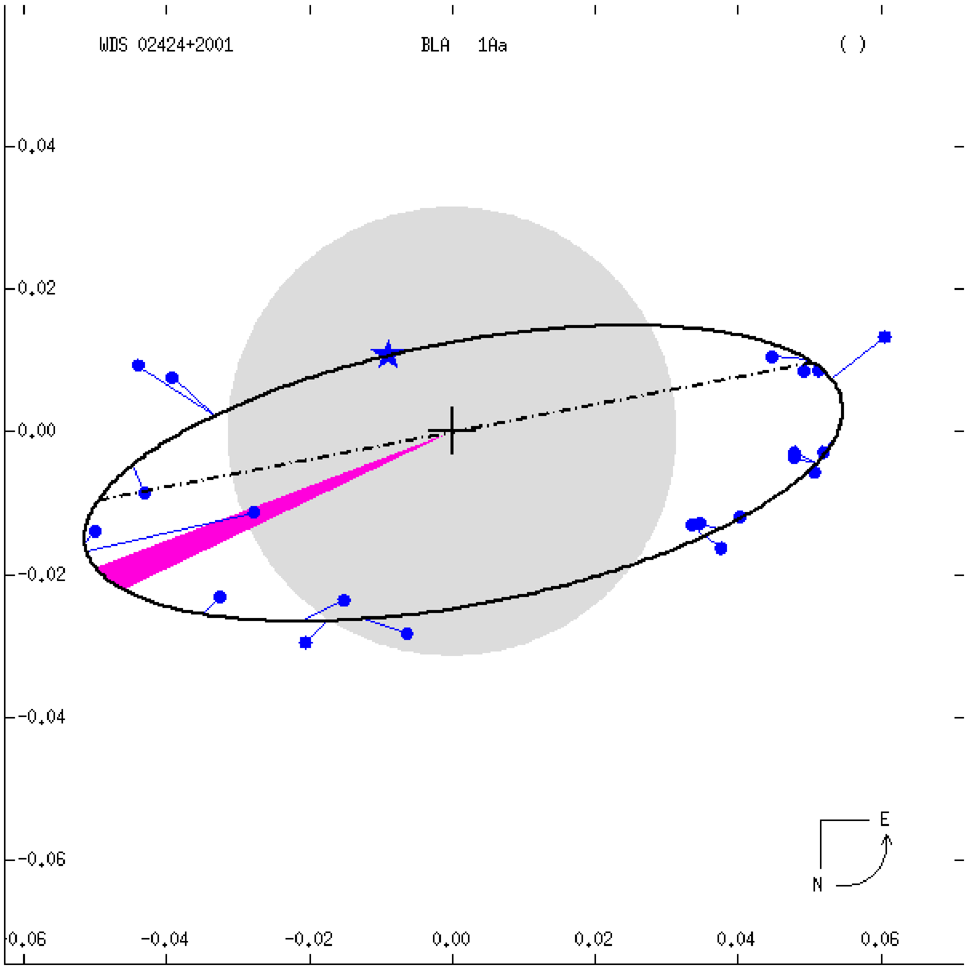


SFP3: μ Ari



- CHARA Array data is from October 2007.
- The dashed wedge is where the pair is predicted to be from October to December 2009.

SFP3: μ Ari

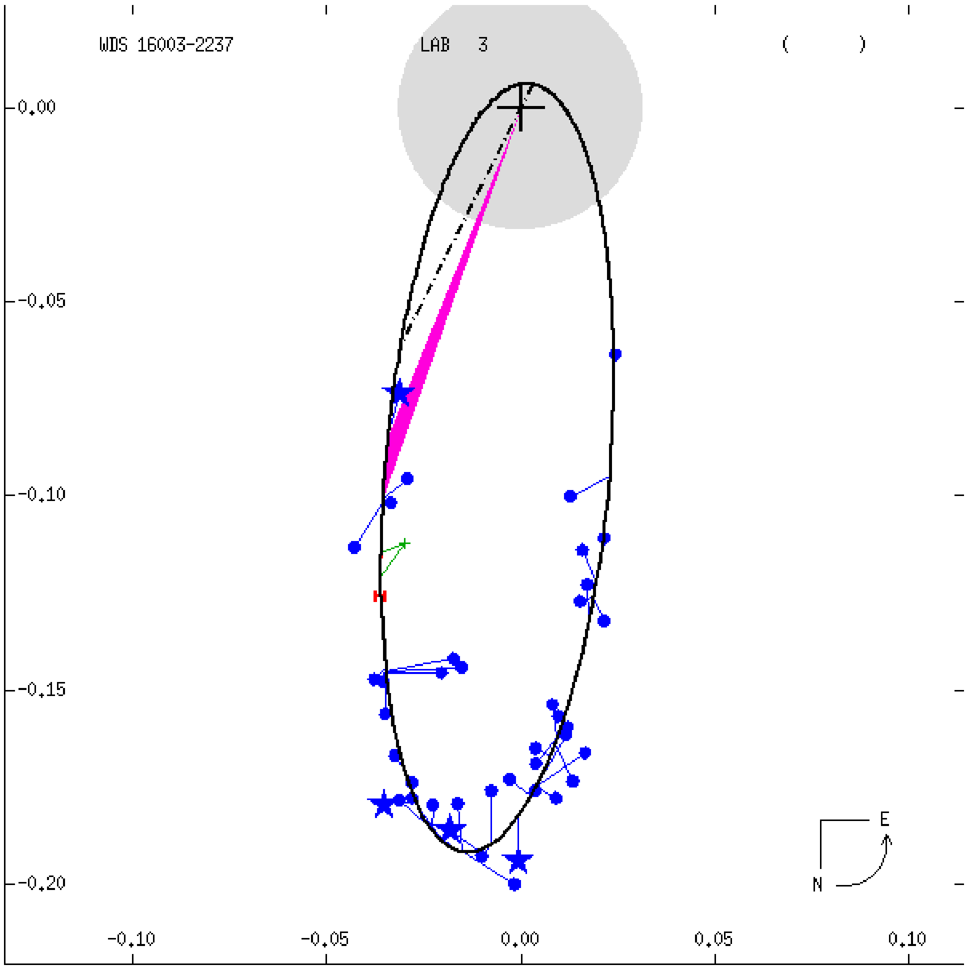


- Although older, the relative orbit (Msn1997a) adequately covers the data. At that time, the pair had completed ~1.5 revolutions.
- With the Array point, the pair has gone through over 3.6 revolutions, which much more significantly constrains the orbital period.
- The sole Array point was at a crucial separation, which places constraints on the inclination.

Possible Future Target: δ Sco

- Filled stars here represent data taken with the USNO speckle camera.

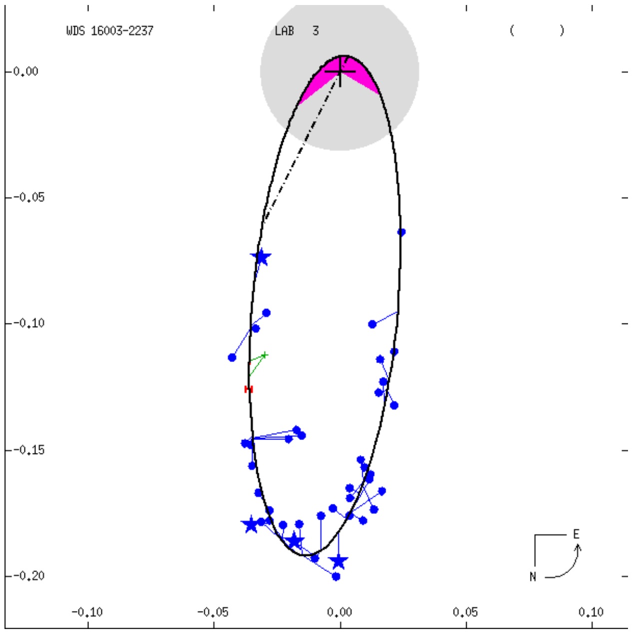
- The four wedges represent predicted positions from April to June 2009-12.



Possible Future Target: δ Sco

- Due to the very high (0.94) eccentricity and the lack of data points to constrain it near periastron, the orbit (Msn2009) was calculated by fixing eccentricity.
- Exhibiting Be star characteristics near periastron, SFP measures over this time will constrain the orbit while possibly provide other opportunities to examine the Be disk (Sch2009, Tou2009).

T	θ	ρ
2011.25	59	18.7
2011.30	79	13.0
2011.35	128	7.8
2011.40	251	6.9
2011.45	297	15.5
2011.50	310	23.5



Other Possible Targets

$V < 7$

$\delta > -20$

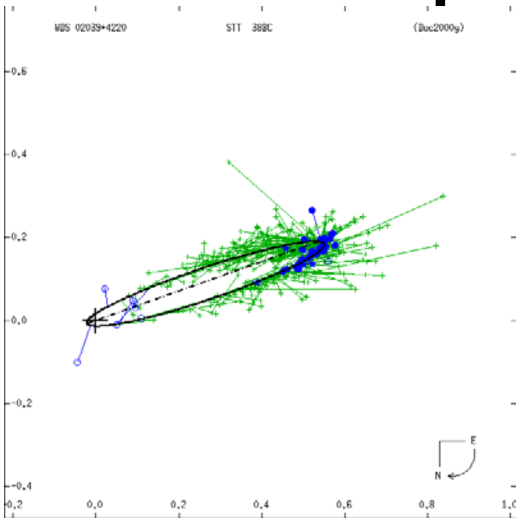
$N > \sim 10$

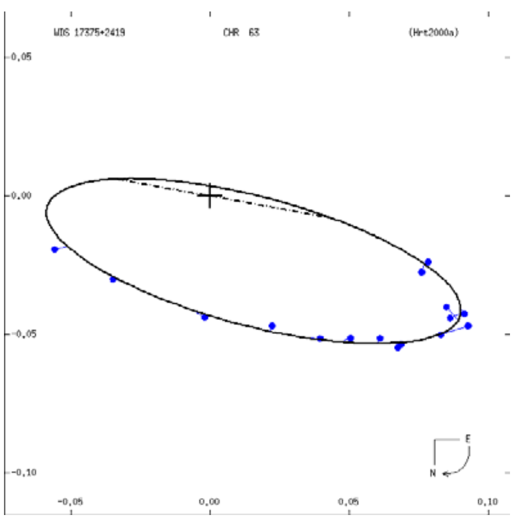
$G > 1$

$10 \text{ mas} < a_{\text{periastron}} < 30 \text{ mas}$

HD 4775	HR 404	γ^2 And
31 Ari	τ Per	ζ Aur
104 Tau	η Ori	115 Tau
64 Ori	53 Cam	20 Leo
23 Com	HD 125632	HD 128563
ζ Boo	HD 157482	79 Her
100 Her	HR 6814	HR 7048A
HR 7048B	HD 178911	δ Sge
HR 7784	λ Cyg	HD 205314

Properties of “Other” Targets





- Of these, some may be inappropriate due to large Δm in K band, e.g., HR 233, δ Sge.
- These typically fall into two broad categories:
  - Long period, high e systems with a small observation window, and
    - γ^2 And at top left, P ~ 64 y, T_0 ~ 2016
  - Shorter period, lower e systems that happen to spend large fractions of their orbit closer than 30 mas.
    - 79 Her at bottom left, P ~ 10 y, T_0 ~ 2014

References

- Hrt1989 = Hartkopf et al. 1989 AJ 98, 1014
- Lab1974 = Labeyrie et al. 1974 ApJ 194, L147
- McA1979b = McAlister 1979 ApJ 230, 497
- Msn1997a = Mason 1997 AJ 114, 808
- Msn2009 = Mason et al. 2009 AJ 137, 3358
- Mut2008 = Muterspaugh et al. 2008 AJ 135, 766
- Pbx2000b = Pourbaix 2000 A&AS 145, 215
- Scf1991 = Barlow & Scarfe 1991 AJ 102, 2098
- Sch2009 = Schaefer et al. 2009 AAS #213, #409.09
- Tok2000 = Tokovinin et al. 2000 SvAL 26, 116
- Tou2009 = Touhami et al. 2009 AAS #213, #409.18